# Counting Errors in Radioactivity Analyses

Radiochemical analyses of drinking water, as part of their methods, include the determination of counting errors (CEs). CEs reflect the randomness of the decay of radionuclides and are a statistical expression of the variability in analytical procedures that exists when radioactivity is measured.

CEs are independent of the Detection Limit for Purposes of Reporting (DLR), which is the level at which CDHS is confident about the quantity being reported.

## Are CEs reported to CDHS along with other results?

Yes. Because CEs are part of radiochemical analyses, the complete reporting of results of all radionuclides by laboratories must include the reporting of CEs. Reporting CEs provides additional information to the reported results, in that they give a sense of measurement conditions.

In addition, the gross alpha CE is used in determining if gross alpha results may be used in lieu of uranium and other further radionuclide monitoring (i.e. gross alpha screening).

> *NOTE: When uranium is analyzed by chemical (mass) methods (not radioactivity), no CE is reported. The result of the chemical analysis (in µg/L) needs to be converted to activity (pCi/L) by multiplying it by a 0.67 conversion factor. This is the only exception for not reporting a CE.*

## How are results submitted?

Laboratories that conduct the analysis submit results and CEs to CDHS via electronic data transfer (EDT). See: http://www.dhs.ca.gov/ps/ddwem/EDT/default.htm

CDHS' Write-On program has STORET numbers for radiological constituents and their CEs to enable easy data entry and submittal.

Results at or above DLRs are required to be submitted to CDHS by EDT (CEs too).

**What about CEs for combined radium-226 and radium-228?**

The radium MCL is based on the sum of radium-226 and radium-228. Although the two isotopes are determined independently and by different methods, a combined CE should be submitted along with the combined result to complete the data submittal.

The combined CE is determined by summing the squares of the CEs of each isotope and then taking the square root of the sum:

$$CE_{\text{combined radium}} = \sqrt{(CE_{Ra226})^2 + (CE_{Ra228})^2}$$

**What about CEs for quarterly averaging?**

When calculating CEs for quarterly averaging, the CE is determined by summing the squares of the CEs for the quarterly results, averaging them, and then taking the square root. Using four quarters as an example, the CE would be:

$$CE_{\text{quarterly average}} = \sqrt{\frac{(CE_{qtr1})^2 + (CE_{qtr2})^2 + (CE_{qtr3})^2 + (CE_{qtr4})^2}{4}}$$

**What about negative values and values below the DLRs?**

Negative values and other values below DLRs may also be submitted. Their CEs should be submitted.

If findings below DLRs are not submitted, the CEs should still be submitted for a complete analytical report.

Negative values may occur since sample counts are compared to background counts, and background counts reflect naturally occurring radionuclides and cosmic radiation that are detected by laboratory instrumentation. Samples that are not different from background may have a negative value when background radioactivity is subtracted.

**How is compliance with gross alpha MCL is determined?**

When gross alpha is used for screening, 0.84(CE) is added to the reported value to give an "assigned value." Laboratories do not report 0.84(CE).

The value of 0.84(CE) is the 95% one-tailed confidence interval for the CE (i.e.,1.65/1.96 = 0.84).

For example:

| Analyte | Result ± CE (pCi/L) | 0.84(CE) | Assigned Value (pCi/L) |
|---|---|---|---|
| Gross alpha | 4.0 ± 0.5 | 0.4 | 4.4 |

The "assigned value" is used in determining compliance with the gross alpha MCL, and for evaluating uranium and radium, as described in 22 CCR .

**How are CEs determined?**

Radiochemical counting follows Poisson statistics. Thus, the standard deviation (SD) of a result can be determined based on a single analysis of the sample.

The CE is derived by combining the SD of the sample count and the SD of the background count; 2σ CE represents the 95% the confidence interval for the analytical result.

For gross alpha analysis, CE (= 95% CE) is calculated as follows:

$$\text{95\% Counting Error} = 1.96\frac{\sqrt{\left(CMP_\alpha / TS\right)^2 + \left(BKG_\alpha / TB\right)^2}}{2.22(\varepsilon_\alpha)(\text{Volume})}$$

where

$CMP_\alpha$ = sample alpha counts per minute
$BKG_\alpha$ = background alpha counts per minute
$T_S$ = sample count time
$T_B$ = background count time
2.22 = factor converting disintegrations per minute to pCi
$\varepsilon_\alpha$ = alpha efficiency
Volume = sample aliquot (liters)